



Innovation for Our Energy Future

Western Wind and Solar Integration Study



Dr. Debra Lew

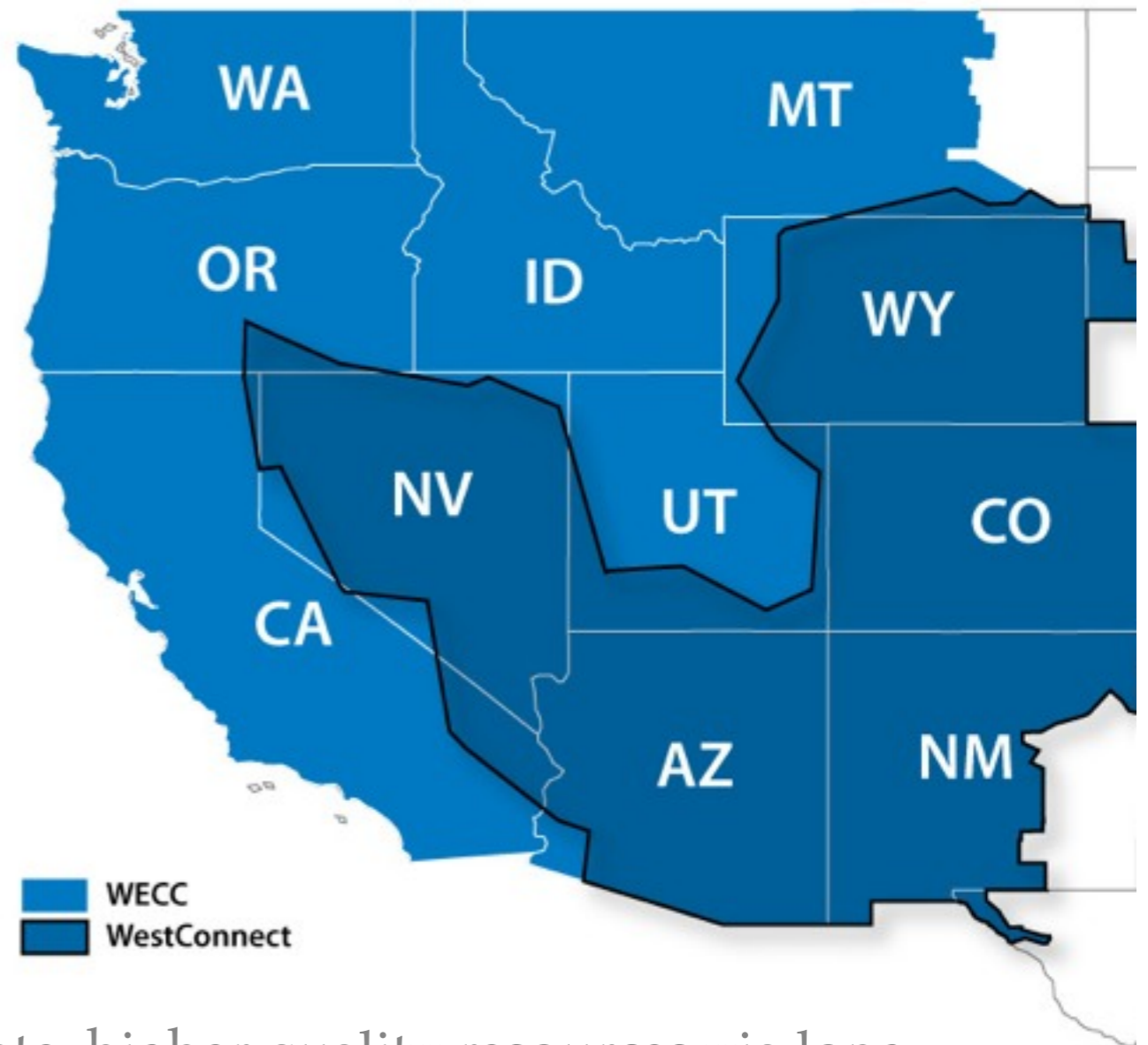
**National Renewable
Energy Laboratory**

WWSIS Public Release

May 20, 2010

Can we integrate 35% wind and solar in the West?

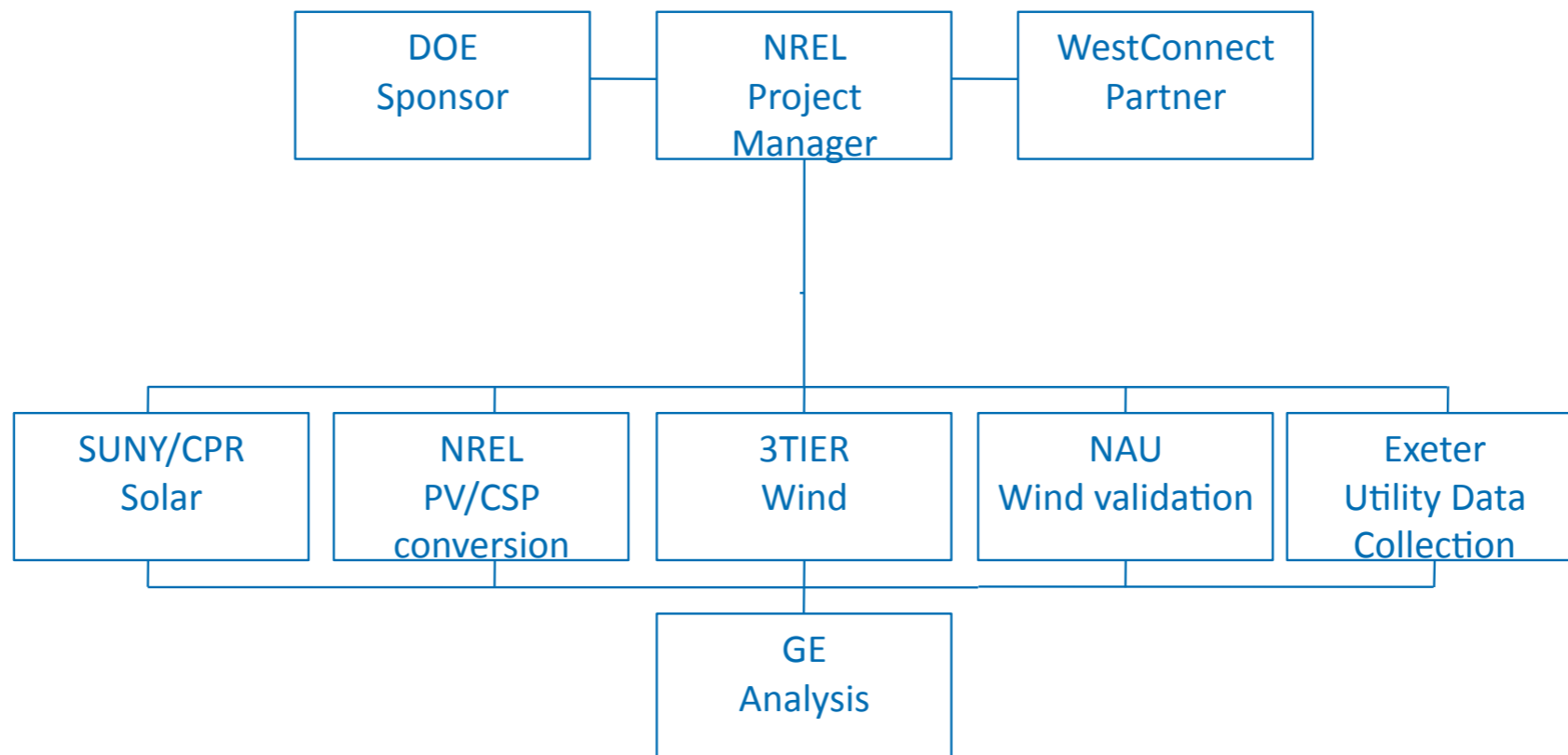
Goal - To assess the operating impacts and economics of wind and solar on the WestConnect grid



- How do local resources compare to remote, higher quality resources via long distance transmission?
- Can balancing area cooperation help manage variability?
- Do we need more reserves?
- Do we need more storage?
- How does geographic diversity help?
- What is the value of forecasting?

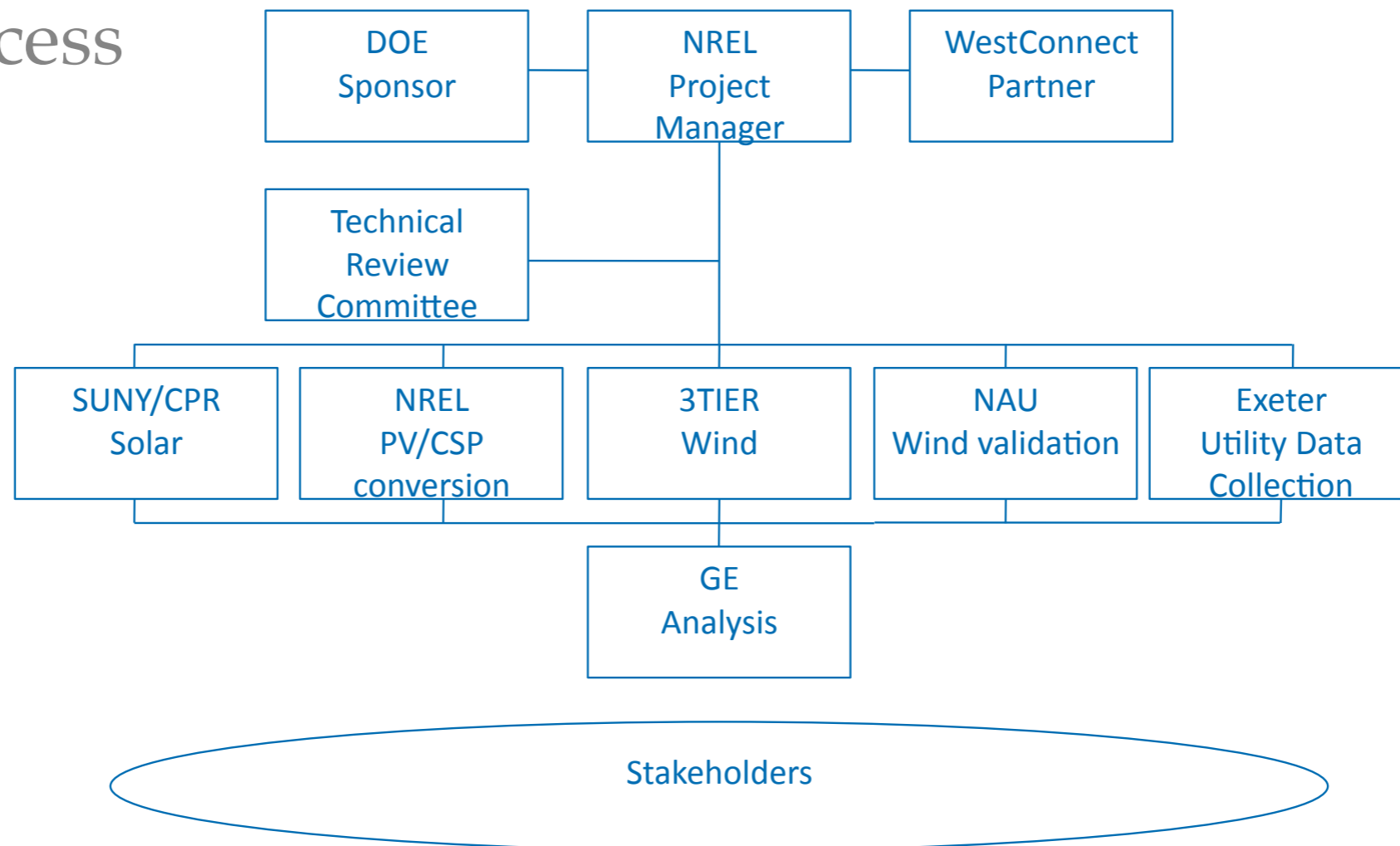
Rigorous Study Approach

- Expert study team



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- Technical Review Committee and Stakeholder process



Rigorous Study Approach

- Expert study team
- Technical Review Committee and Stakeholder process
- High resolution database - wind, solar, load
- Statistical analysis and simulations of power system operations
- Modeled WECC power system for the year 2017

Scenarios

Name	WestConnect		Rest of WECC	
	Wind	Solar	Wind	Solar
10%	10%	1%	10%	1%
20%	20%	3%	10%	1%
30%	30%	5%	20%	3%

Penetration levels are by energy, not capacity.

Solar is 70% concentrating solar power with thermal storage and 30% rooftop photovoltaics

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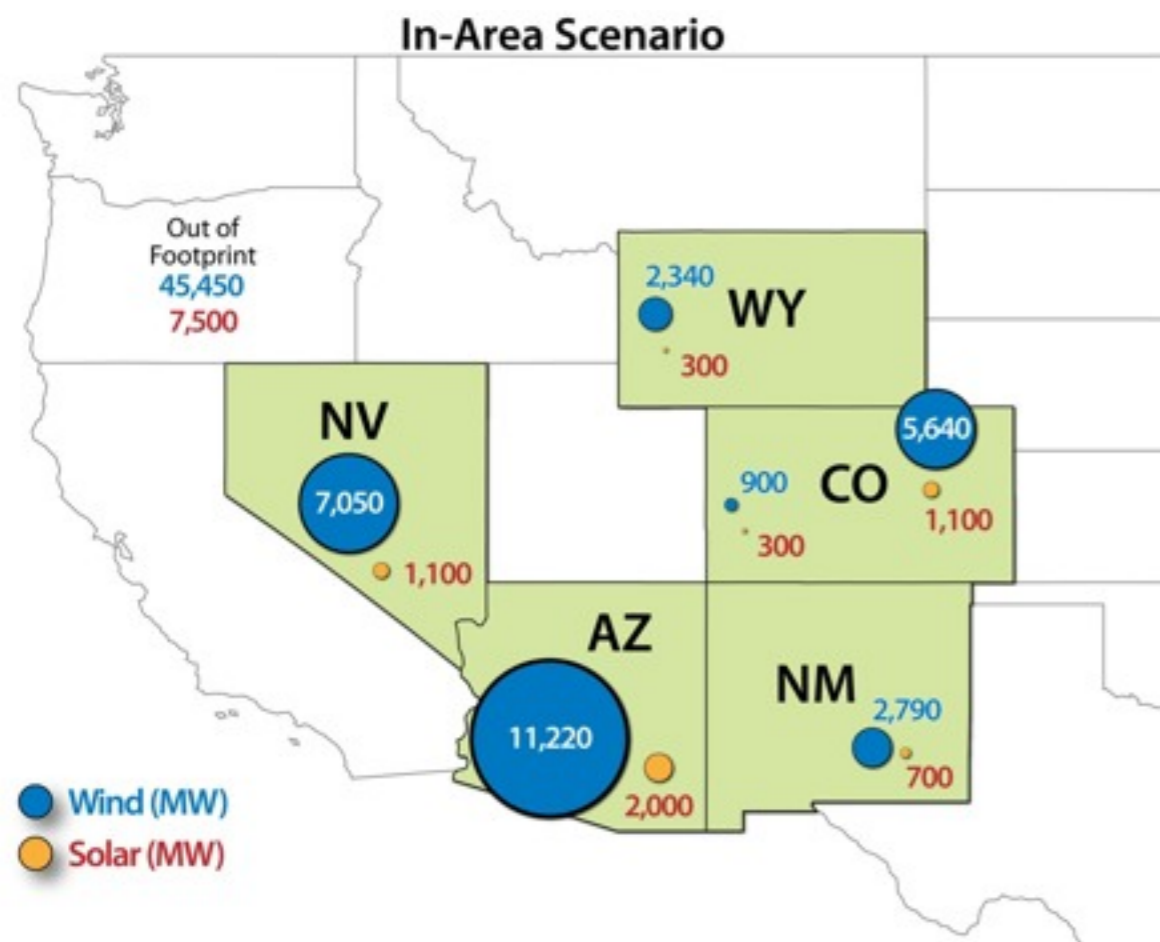
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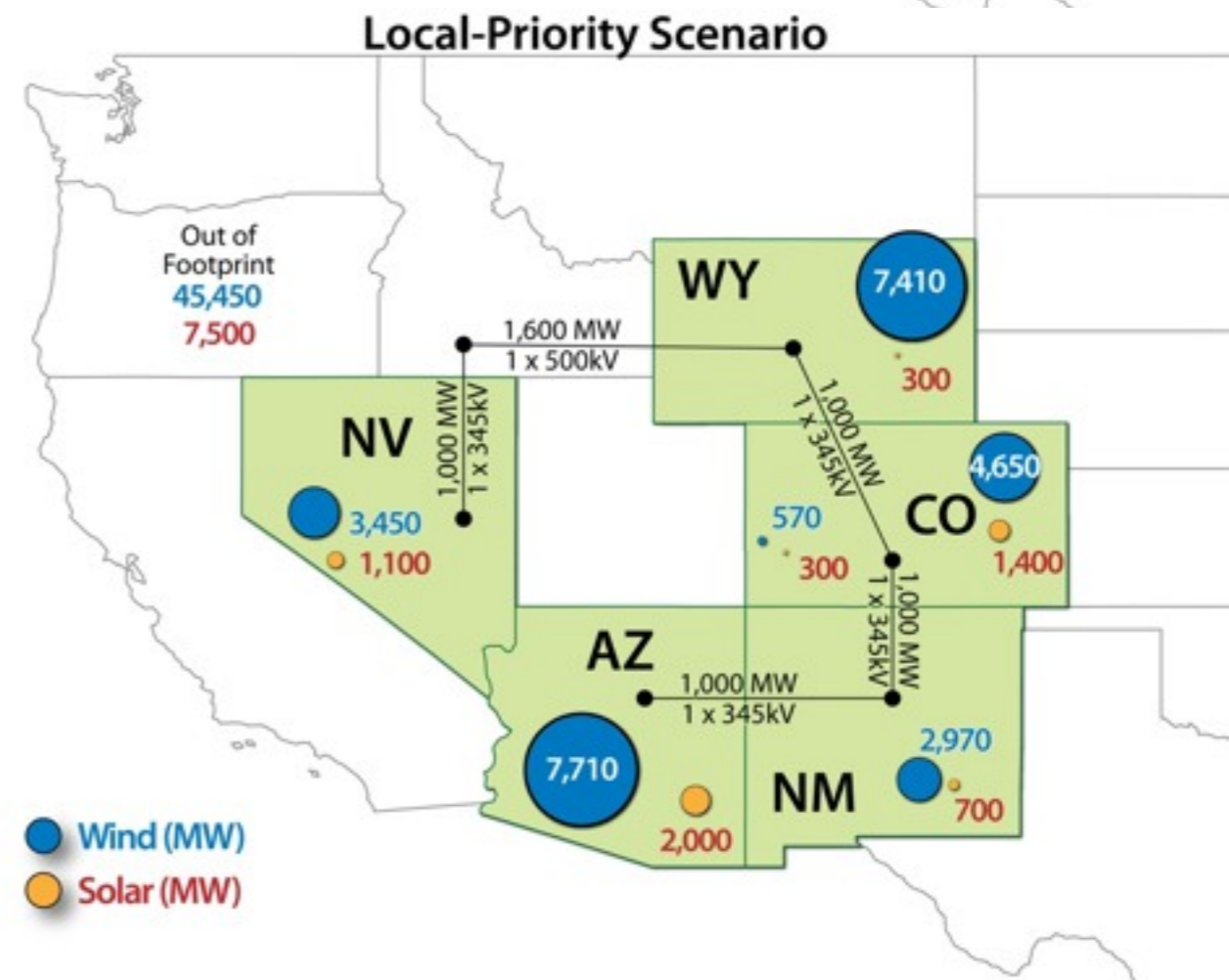
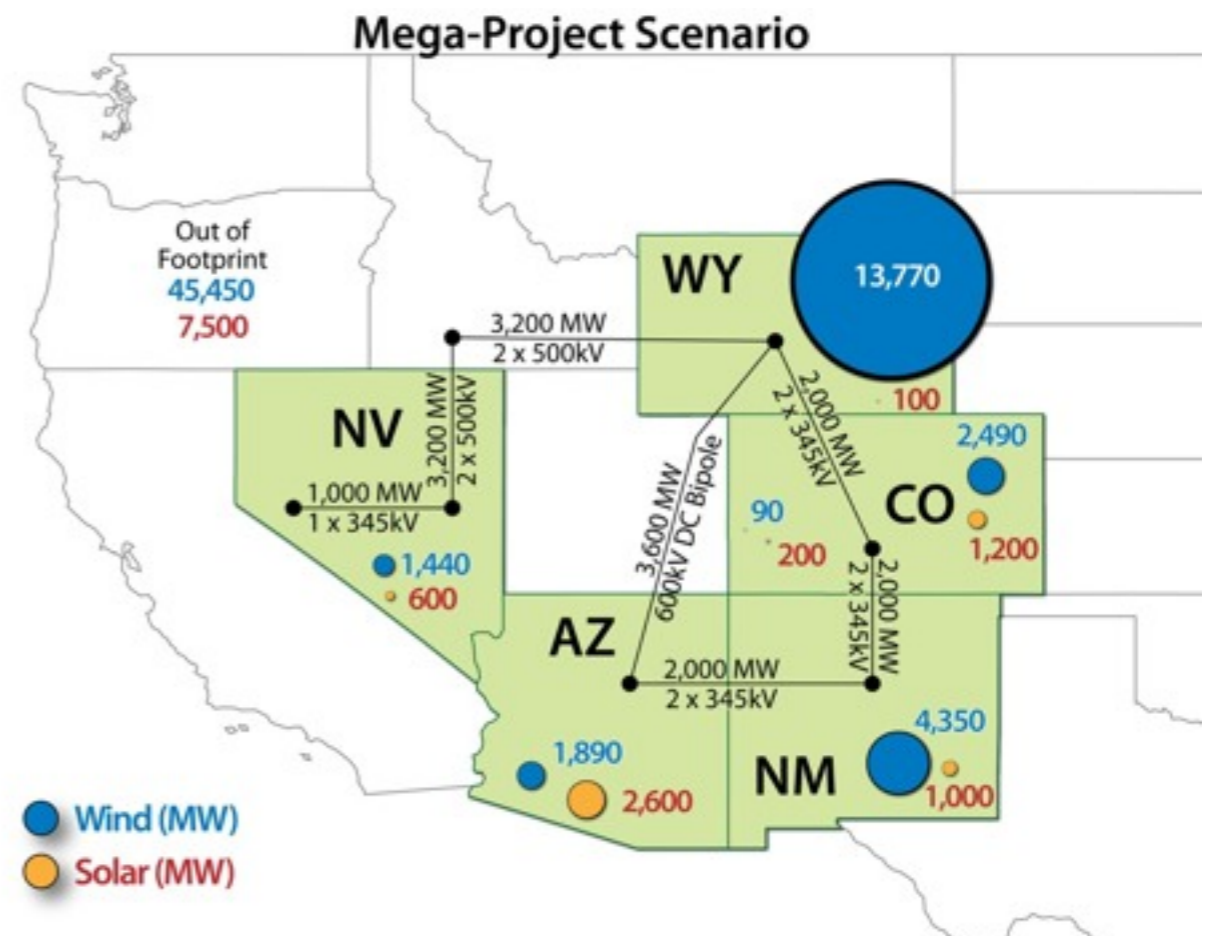


30% Wind/ 5% Solar Scenarios

In-Area - each state meets target from sources within that state

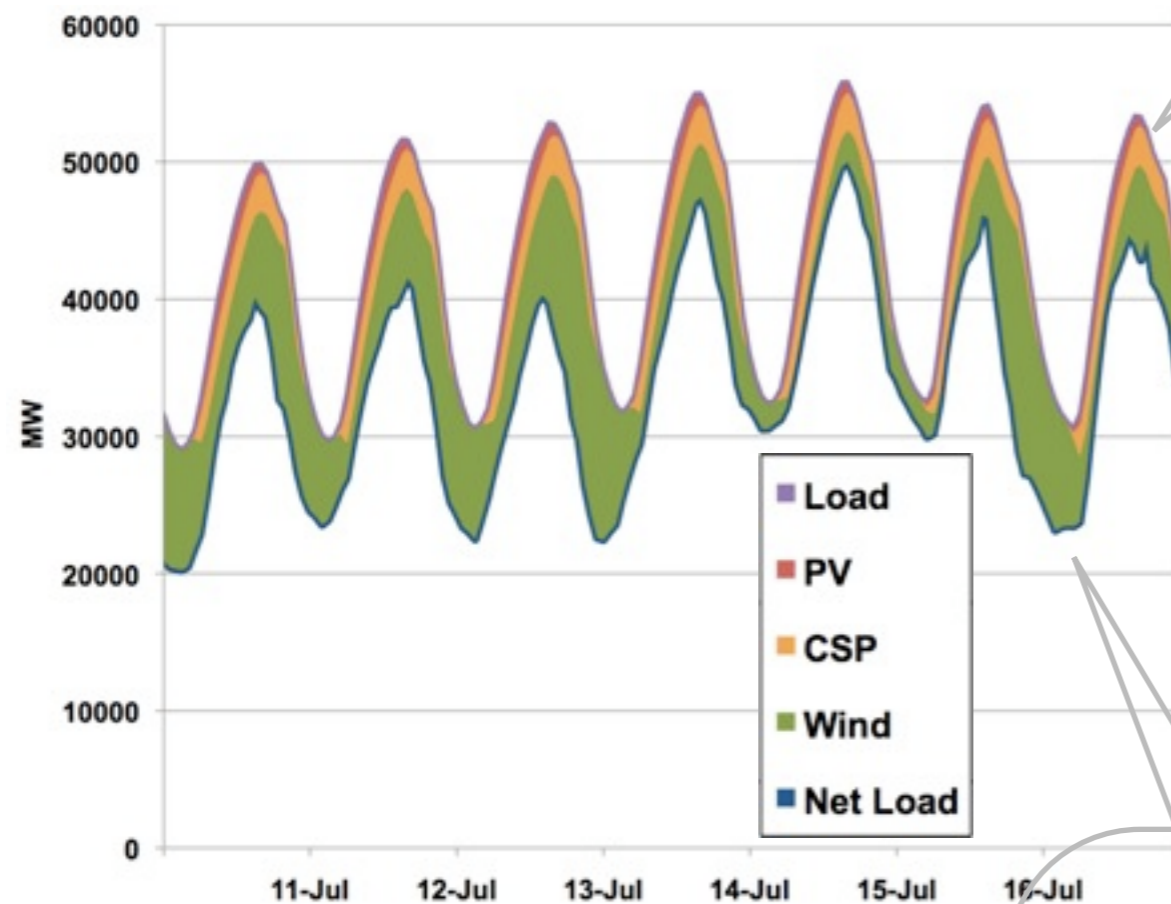
Mega Project - concentrated projects in best resource areas

Local Priority - Balance of best resource and In-Area sites



How does the system operate with 35% wind and solar?

Mid-July



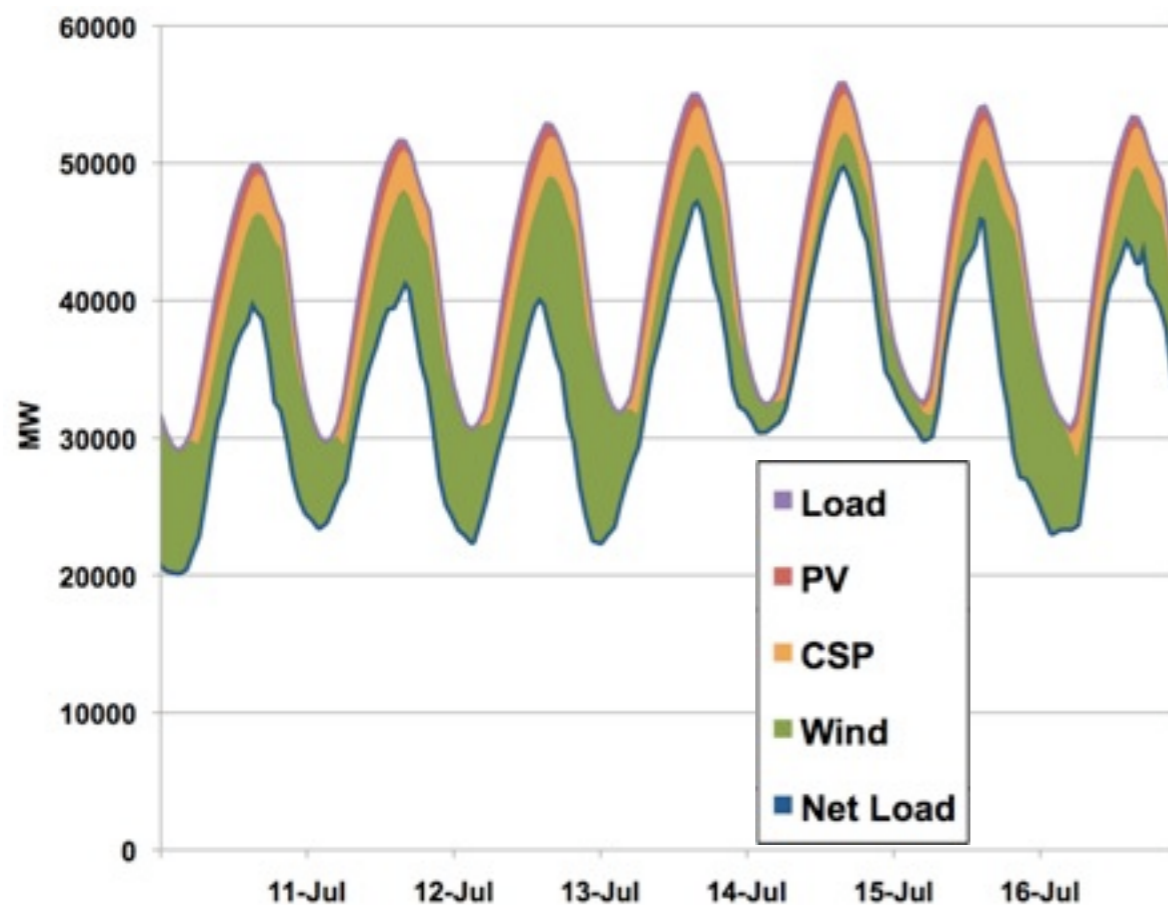
Load

The operator formerly managed to load but now has to manage the net load

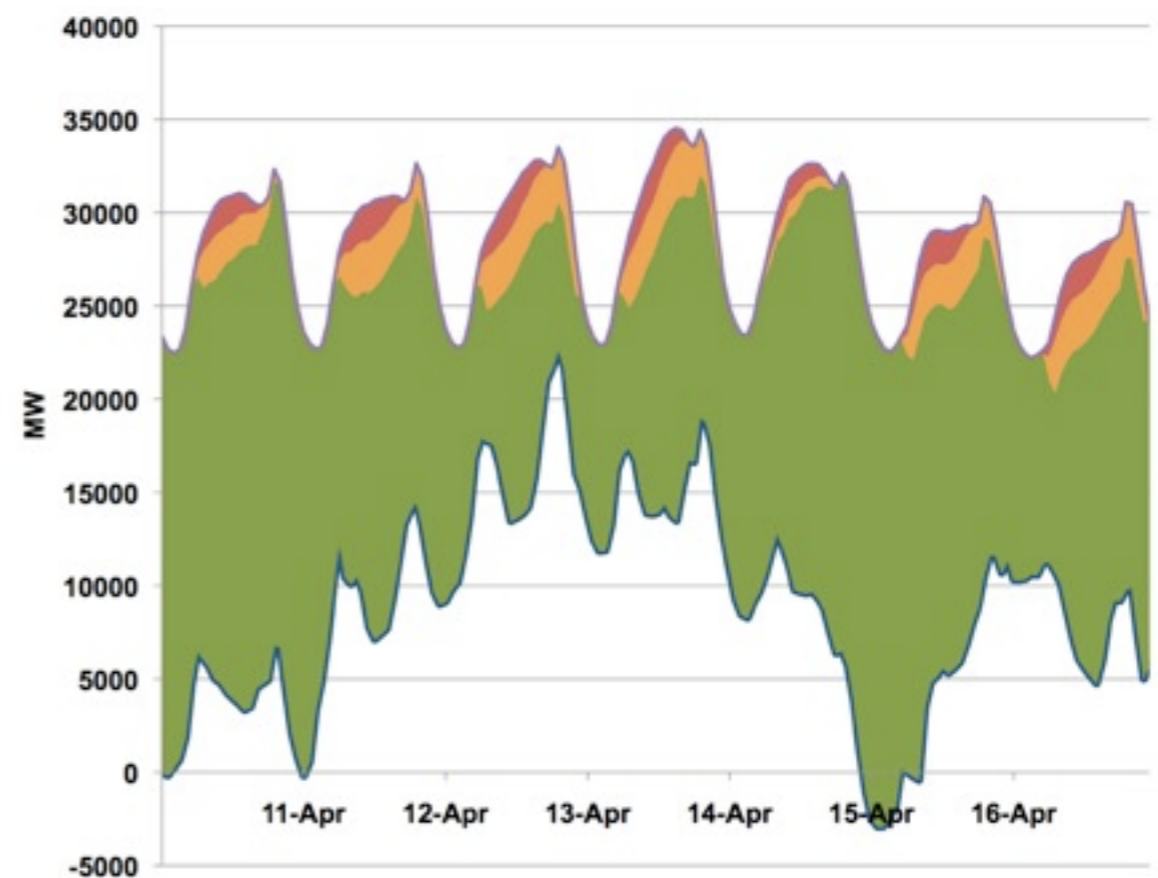
$$\text{Net Load} = \text{Load} - \text{Wind} - \text{Solar}$$

How does the system operate with 35% wind and solar?

Mid-July



Mid-April

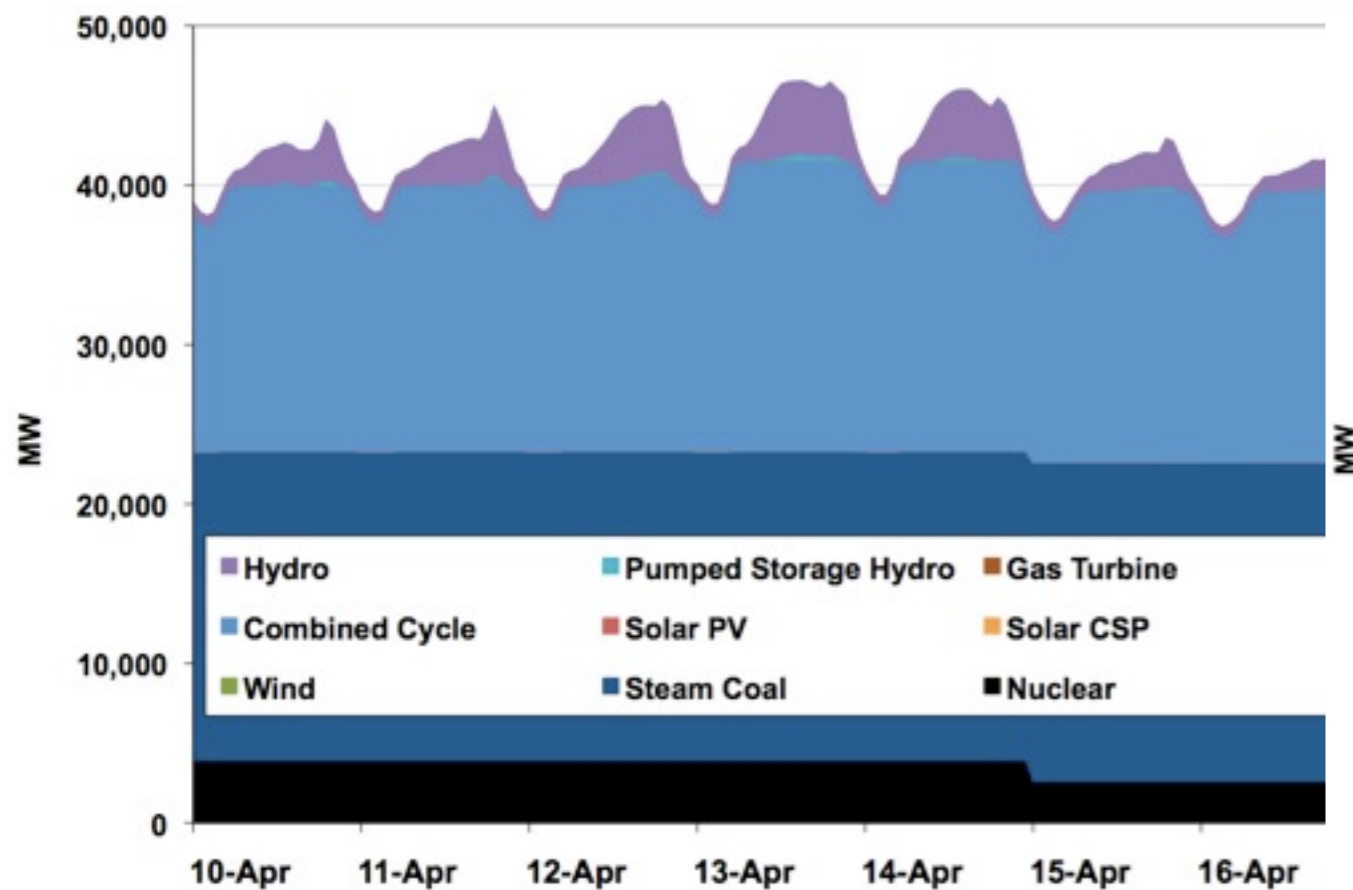


Mid-April shows the challenges of operating the grid with 35% wind and solar.

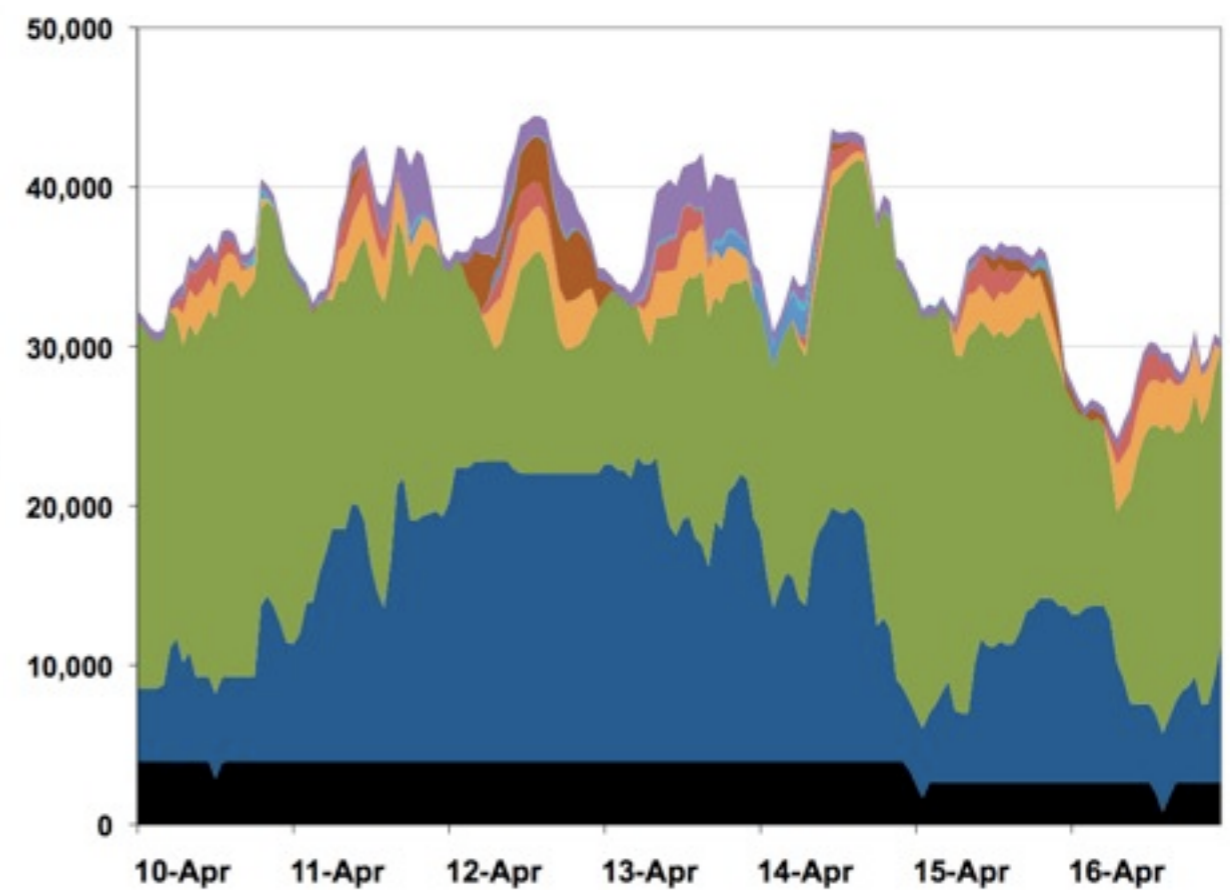
This was the worst week of the 3 years studied.

Operations during mid-April

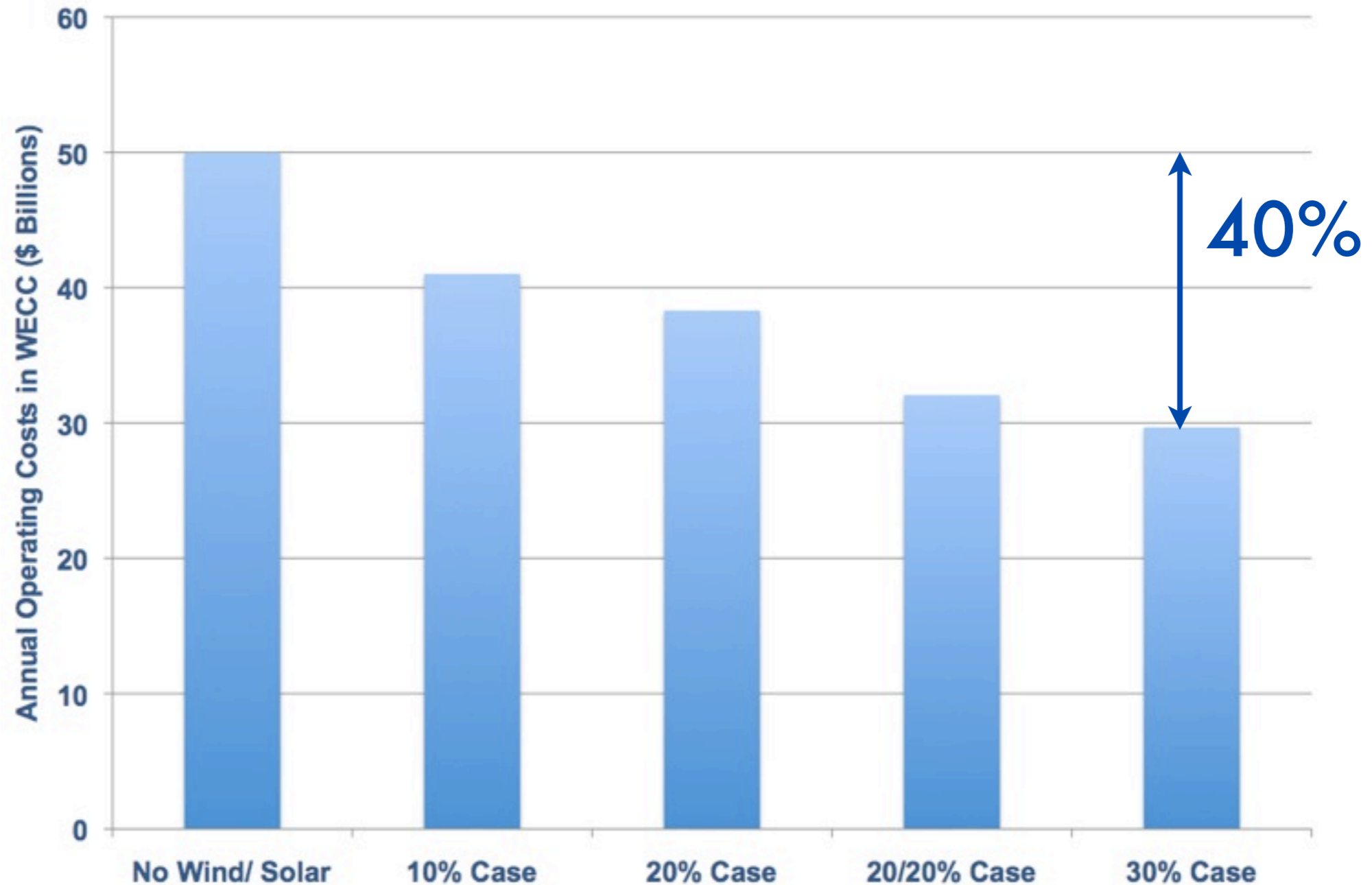
No Wind/Solar



35% Wind/Solar



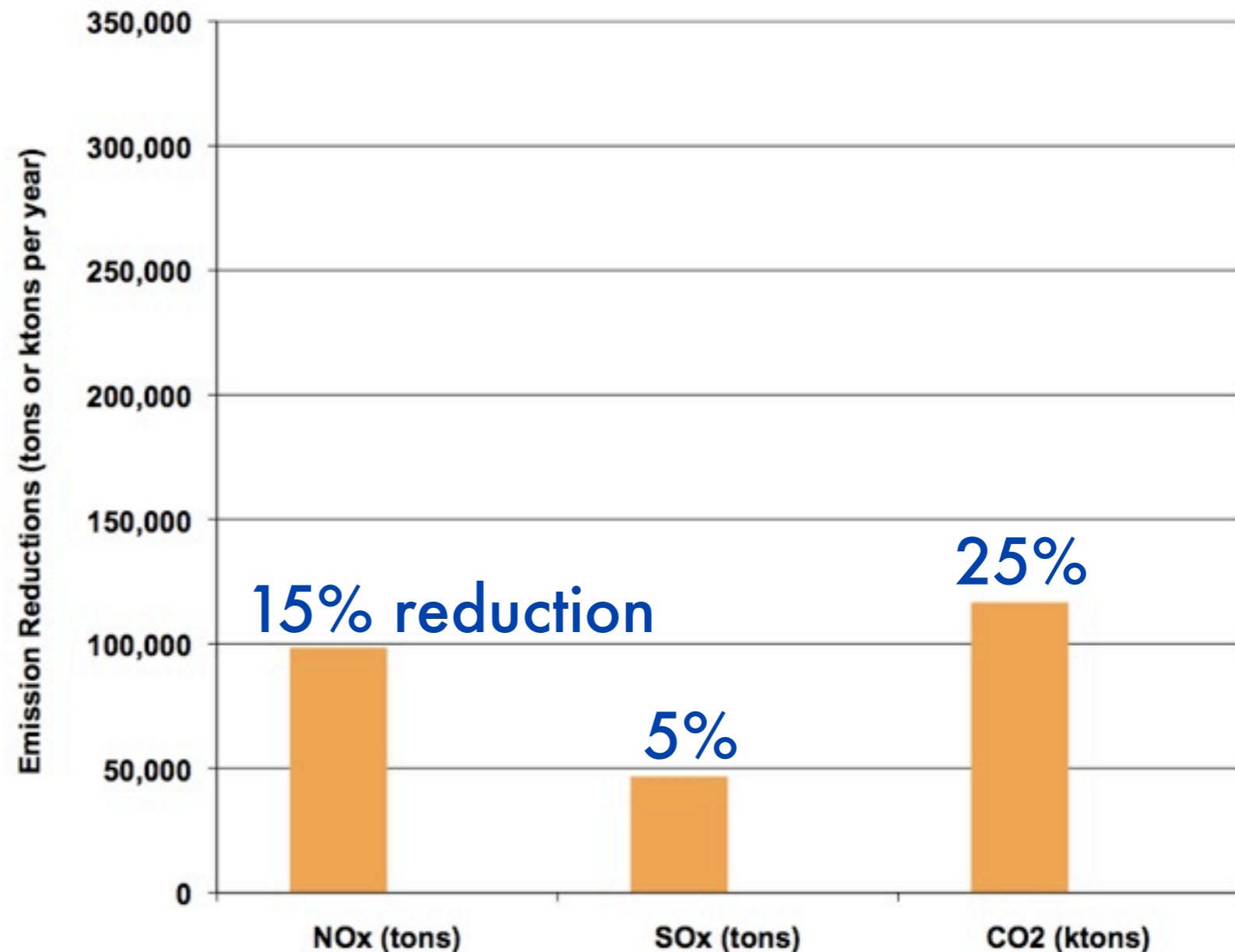
30% Case Saves 40% of Fuel and Emissions Costs



Assuming \$30/ton CO₂ tax

30% Case Reduces CO₂ by 25-45%

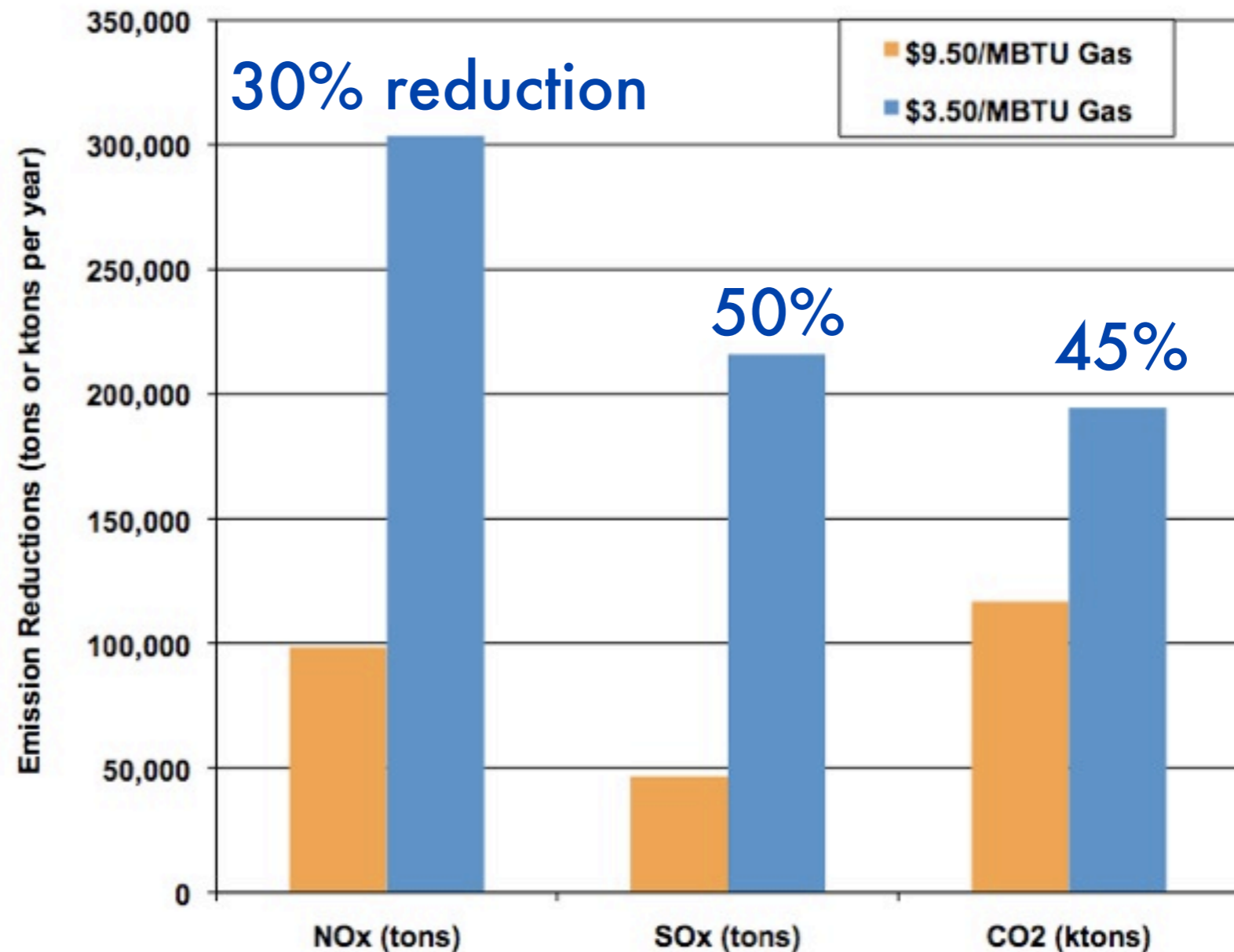
At a \$9.50/MBTU gas price, wind/solar displace gas, resulting in modest emissions reductions.



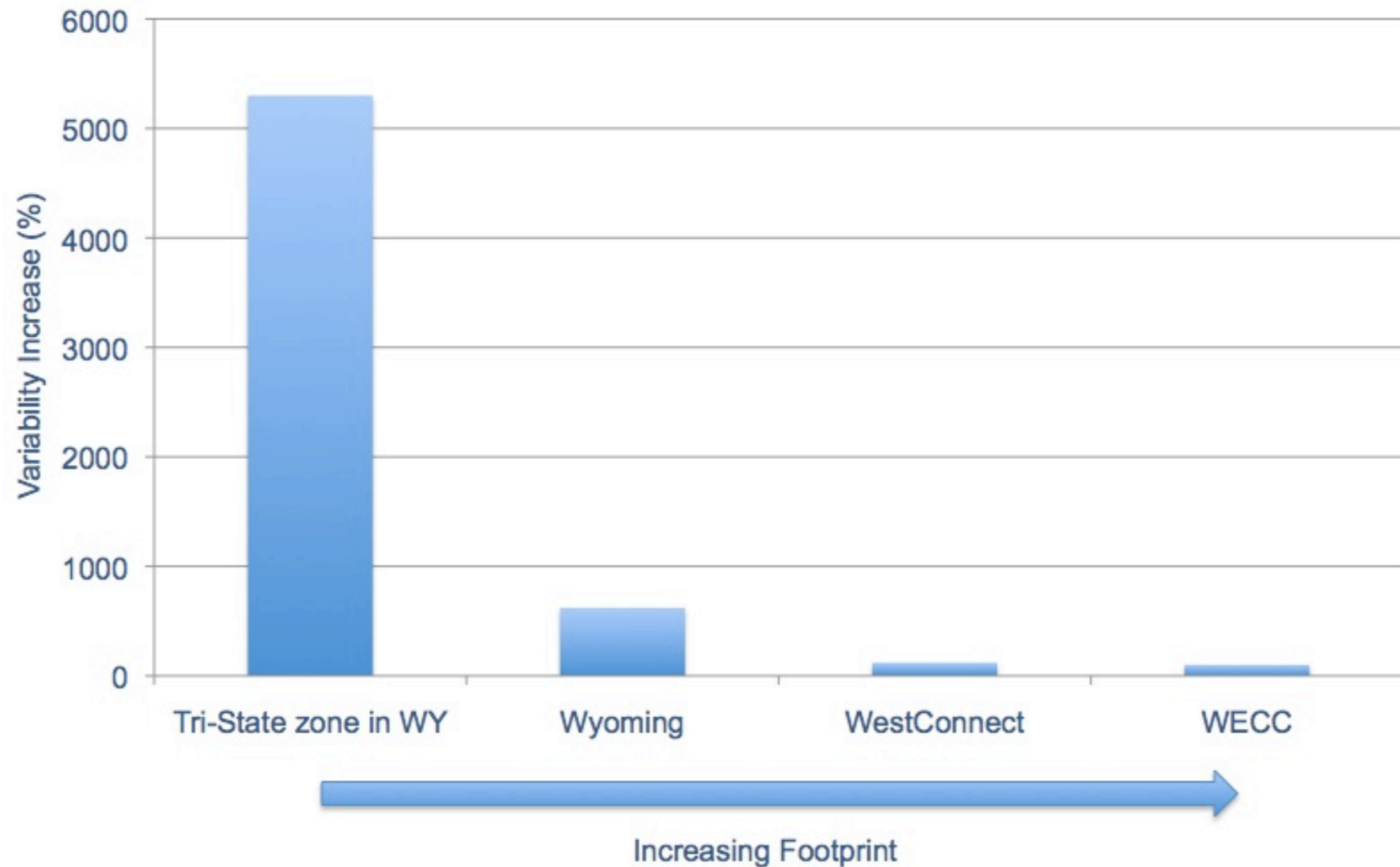
30% Case Reduces CO₂ by 25-45%

At a \$9.50/MBTU gas price, wind/solar displace gas, resulting in modest emissions reductions.

At a \$3.50/MBTU gas price, coal is displaced, resulting in high emissions reductions.



Variability Decreases With Larger Footprints

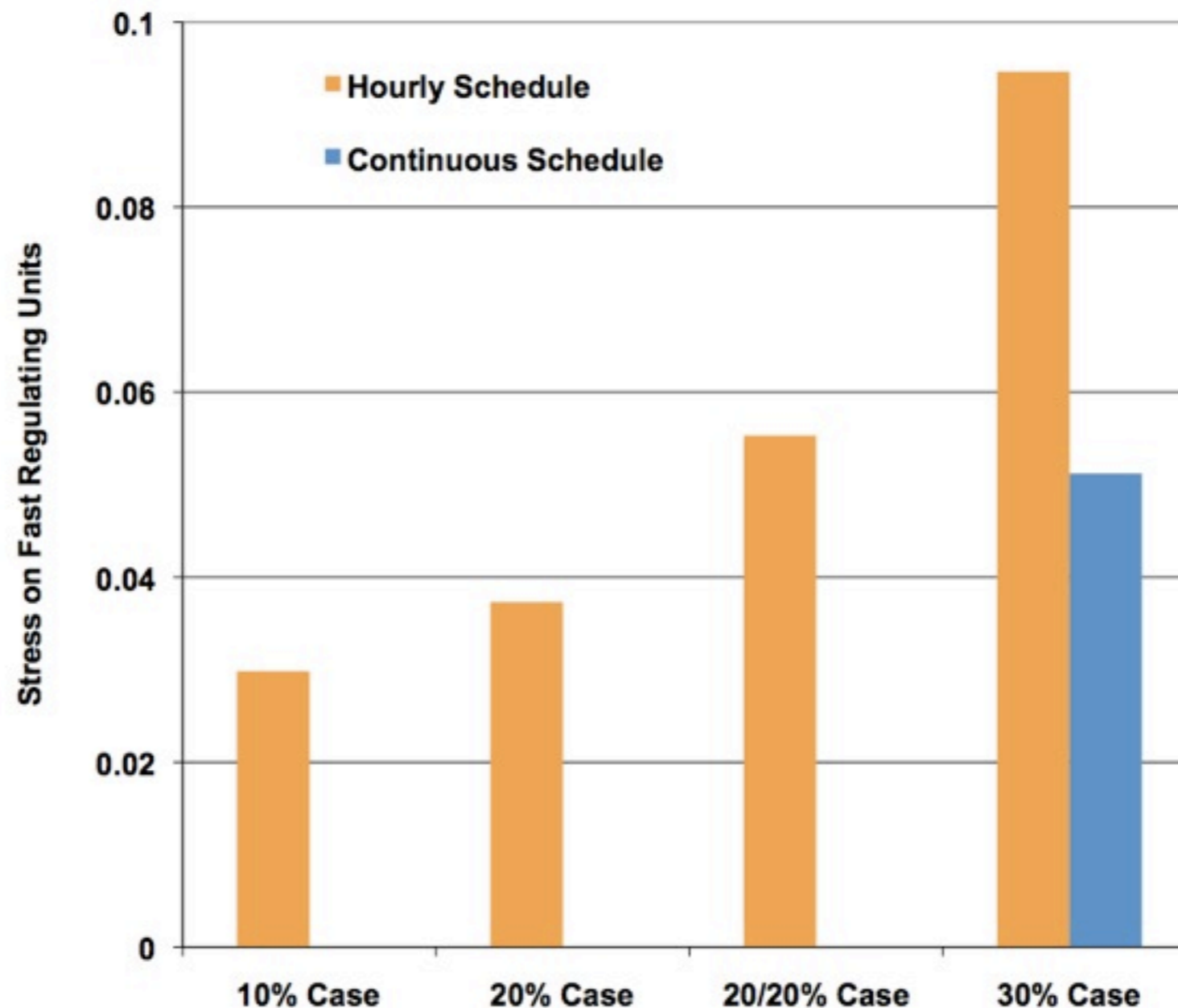


Balancing Over Larger Footprints Saves Money



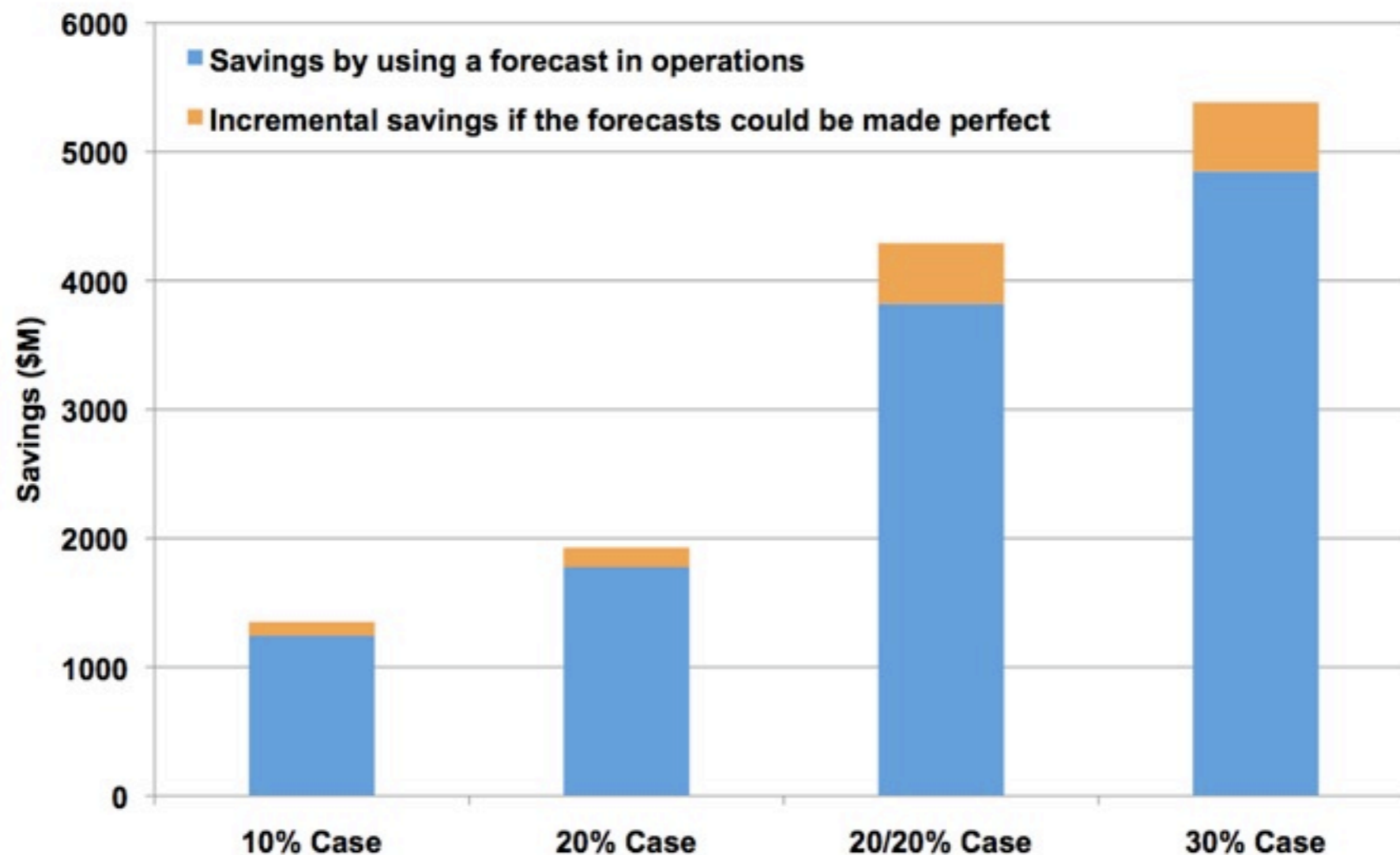
10% Case

Scheduling More Often Than Hourly Reduces Need for More Fast Reserves



Hourly scheduling puts more stress on the fast regulating reserves than the wind and solar variability does

Using a Forecast in Operations Can Save Up to 14%



If forecasts were perfect,
an additional 1-2% could be saved

Impact of Uncertainty on Operations

- On average, aggregated wind forecasts are good
- But occasionally, the forecasts are too high or too low
- Severe under-forecasts can lead to curtailment or spilling of wind/solar
- Severe over-forecasts can result in inadequate contingency reserves

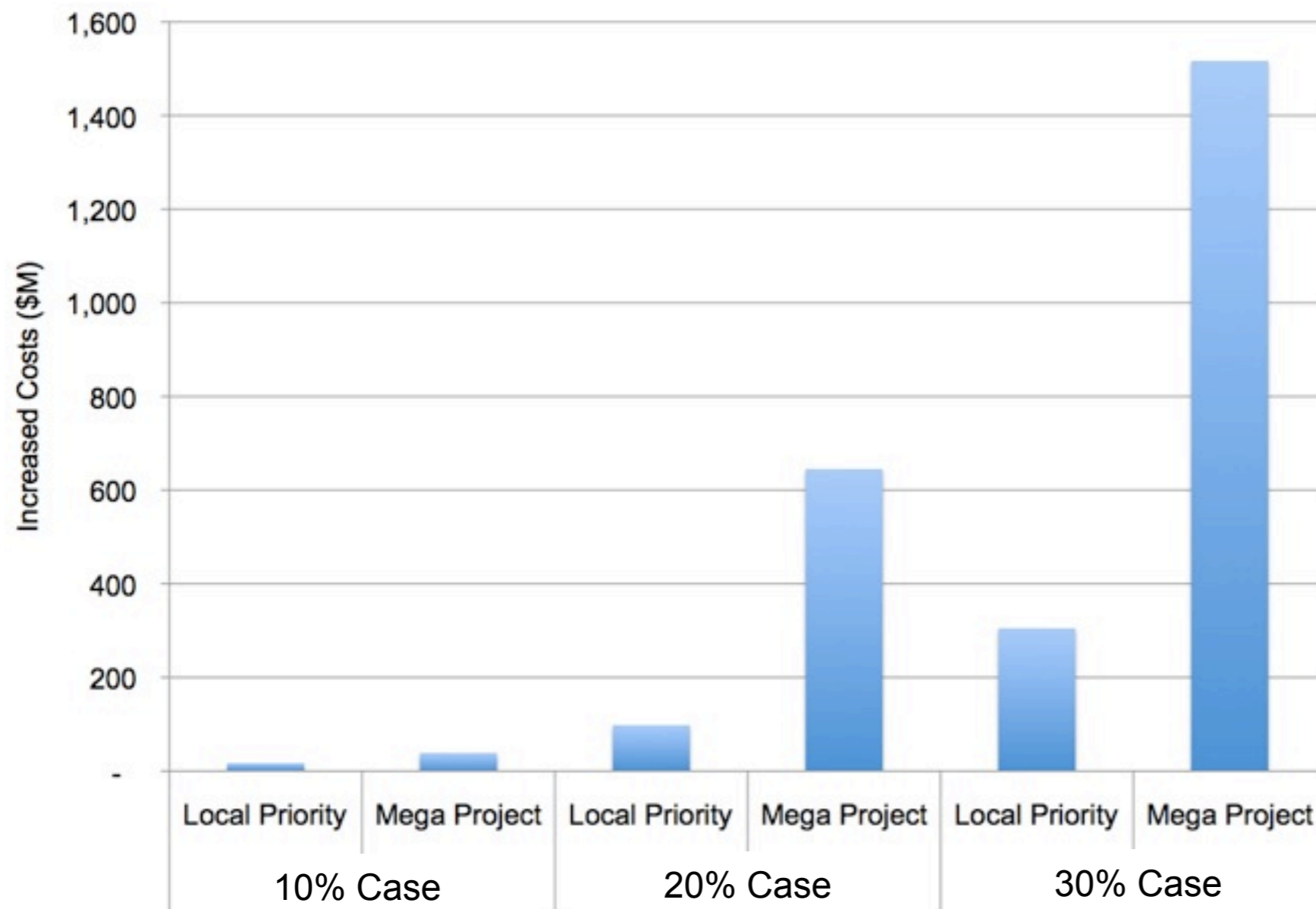
Demand Response as an option to mitigate contingency reserve shortfalls

- Increase spinning reserves for 8760 hours of the year
- Add storage like pumped hydro or compressed air energy storage
- We only have shortfalls for 89 hours of the year (1%), so these options can be expensive
- Demand response (paying loads to turn off) was found to be effective and was less expensive

Impact of Variability on Operations

- Wind and solar double the variability reserve requirement (load following).
- However, because wind and solar cause some generators to be turned down, rather than turned off, the system actually has more up-reserves than it does in the no wind / solar case.
- Therefore, we do not find a need to commit additional reserves to cover variability.

Better Utilization of Existing Transmission Reduces Need for New Transmission

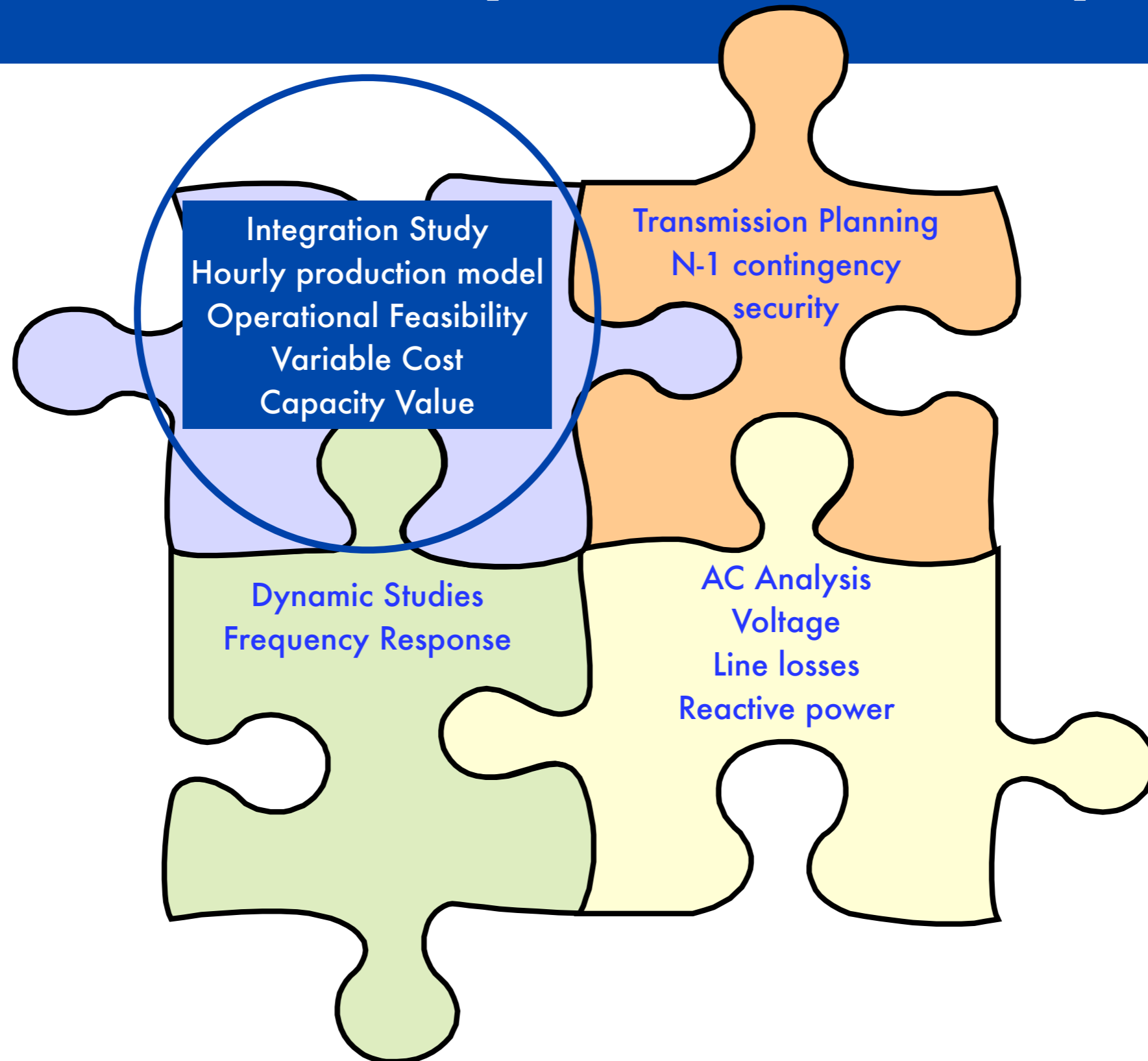


We can start integrating up to 20% wind/3% solar before interstate transmission is commissioned, assuming better utilization of existing transmission

35% Wind and Solar Can Work If Changes Can Be Made

- 30% wind and 5% solar are operationally feasible in WestConnect if changes to operational practice can be made, including:
 - Substantially increase balancing area cooperation or consolidation, real or virtual
 - Increase the use of intra-hour scheduling of generation and interchanges
 - Increase utilization of transmission
 - Enable coordinated commitment and economic dispatch of generation over wider regions

This is but one piece of the puzzle



Thanks!

- Study Team - GE Energy, 3TIER Group, SUNY / CPR, Exeter Associates, Northern Arizona University, NREL
- Technical Review Committee
- WestConnect
- U.S. DOE
- For More Info: <http://www.nrel.gov/wwwsis>